Evaluating how universities engage school students with science

A model based on the analysis of the literature

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Every year fewer students are electing to take university level science courses, particularly physics. This situation has led universities and employers to try and encourage more students into science subjects through the development of numerous science outreach initiatives such as guest lectures and summer schools. Much of this work is of an ad-hoc nature, with little understanding of the underlying motivations and conditions that guide students' subject selection. Therefore, we have analysed a range of literature sources to develop a simple model for school student engagement that can help guide university-initiated science outreach programmes. This model takes into account factors such as the different life stages of the student, the myriad influences that affect career decisions, and resource availability. As part of this work we also present an overview of the research around increasing progression into higher education. As experienced practitioners and researchers in science outreach we have developed an easy-to-use set of guidelines that are applicable in the real-world situation of limited budgets, time and staff resources.

Keywords: outreach, widening participation, universities, science, marketing, STEM

Introduction

Universities around the world invest heavily in student recruitment. Often marketing initiatives are run under multiple budget headings including recruitment, outreach, equity and diversity programmes. Overlap in purpose is common, with almost all of these initiatives aiming, ultimately, to increase student participation. However, often there is disparity between the approaches to student recruitment with some areas favouring a mass-target approach and others a personal one-on-one lifetime intervention. In this paper we discuss a model for student recruitment that looks at these approaches and develops a framework of what interventions are most appropriate and when they should be carried out. We describe the literature on factors that influence student decision-making concerning career choice and university attendance. We then bring this disparate information together in a simple model that can be applied across the marketing, recruitment and equity teams to allow them to work together towards a common goal, *viz.* increasing student participation at the tertiary level. In this study we use literature from science and science education as these are areas most familiar to the authors, however this does not preclude the results from being used in other discipline areas.

The problem

The number of students studying a science is decreasing worldwide. This trend is especially prevalent in OECD countries whose governments and universities are expressing concerns over the decreasing numbers of students that are interested in pursuing scientific careers. In the US the numbers of students expressing an interest in science throughout their school career has been decreasing year on year. International comparisons suggest that American students are falling behind their international counterparts; an effect that is concerning at the tertiary education and governmental level (Stake & Nickens, 2005). This effect is particularly noted within the physical sciences where university enrolment growth has been static or experiencing minimal growth, while enrolment in the biological sciences or non-science courses grows rapidly (Stake & Nickens, 2005; Mulvey & Nicholson, 2012). This trend is at odds with international government policies that are looking to science and technology as economic saviours (Business Roundtable, 2005; Higher Education Research Institute, 2010). Science and technology are seen as a new way for economies to generate products and in turn increase the gross domestic product. Without science development many countries fear they will be unable to generate the new high-value products of the future (National Academies, 2005; Bush, 2006; European Commission, 2004; Ministry of Science, 2008). The lack of recruitment of students into science courses at university is attracting high level attention and governments are expecting universities to address this issue.

University marketing is a multifaceted and expanding field. The new economic model of universities as businesses means that many institutions are beginning to charge fees for study (historically more common in the US) and this in turn drives students into the role of consumer (Harrison-Walker, 2010). This drives a feedback loop whereby universities are forced into a highly competitive marketing drive to recruit students (Harrison-Walker, 2010). Research into the factors that influence student choice in the latter years of high school shows that they conform to a 7 'P' marketing model, analysing programme, price, promotion, people, prospectus, prominence and place. Of these factors students prioritise the programme (whether an institution is well-regarded within their chosen field of study) and price (fees, living costs and distance from home) (Maringe, 2006). In response to this consumerist approach from students, universities market extensively to students in their last years of high school. These campaigns are generally based on business-led market theory (concepts such as brand-loyalty, profitability, market segmentation) (Angulo, Pergelova & Rialp, 2010; Bennett & Ali-Choudhury, 2009; Canterbury, 2000). This model pits one university against another and often one faculty against another, in direct competition (as determined by the capitalist model) and does not attempt to engage with the lifelong journey of the student and their educational choices.

Within the larger trend of falling student numbers in sciences there is ongoing concern regarding the participation rates of women and minorities in the physical sciences (National Academies, 2005; Bray & Timewell, 2011; Department of Education, 2006; Mulvey & Nicholson, 2012). This problem is often approached separately from pure recruitment, generally under the banner of equity or widening participation programmes (Cuny & Aspray, 2002; Frieze & Blum, 2002; Gale *et al.*, 2010). The result of this is a duality within the university system, with one arm focussing on increasing recruitment within a marketing or economics paradigm and another arm tackling equity issues by running programmes targeted at a particular type of student (Licata & Frankwick, 1996; Hill, Corbet & St Rose, 2010). While marketing strategies tend to focus on mass-media campaigns and high spending, equity programmes tend to be focussed, individualistic and developed on a limited budget. Often these two sectors within a university or science faculty are working independently of one another and rarely, if ever, are these objectives combined and co-ordinated (Gale *et al.*, 2010). However, as graduate numbers decrease alongside a strong politically-led agenda to increase science and technology student numbers, a new approach to student requirements needs to be undertaken.

This work uses the framework of narrative review to assess the literature around students progressing from the secondary school environment through to university. An extensive review of literature from differing research fields was searched through online databases in order to develop a thorough understanding of current research knowledge surrounding factors that influence student choice and study habits. Database searches included information retrieved from ERIC, PubMed, EconLit, Intute, PsycInfo, Web of Knowledge, ScienceDirect, Scopus and Google Scholar. Evidence was included based on an assessment of the research representing the overall consensus of the given field at the time this article was developed. By combining research from a large variety of sources, with our own experience in outreach development, we suggest a programme that works alongside students to develop and maintain an interest in science that universities can use as a framework for increasing the numbers in science and technology courses. This methodological framework allows the development of an informed rationale for decisions, based on current evidence. While a systematic review of the literature would be considered more robust in terms of overall quality of data, the narrative review allows a wider scope and assimilation of current resources from a wider range of academic fields (Collins & Fraser, 2005). A systematic review necessitates focussed search criteria with the aim of reducing reviewer bias. In the current work, this narrowed perspective would eliminate the ability to synthesise information from diverse sources i.e. from education, science and economics. Indeed the aim was to introduce an author voice to interpret and craft the information into a widely applicable model. Therefore, in this instance the format of the narrative review, with its wider, less-rigid, search criteria was deemed appropriate. The results in this paper differ markedly from others in the area in the diversity of information presented. Most literature focuses narrowly on a single research question, examining the effect of one factor at a time on student engagement (Ferre *et al.*, 2013; Frølich & Stensaker, 2010; Luscombe, Lewis & Biggs, 2013). This paper diverges from these empirically driven studies and strives to take a step back to examine the interplay of multiple factors in a complex behavioural array. For this reason, the results that follow are organised by theme rather than discipline.

The evidence

How do people decide what they want to do for a job and when do they make these decisions? These two questions lie at the heart of any quest to understand how to increase the number of students that study science. Without a comprehensive understanding of how people choose their career path, we can have little hope of changing or influencing their choices. Strangely, this knowledge is often omitted from outreach programme design. We will present an overview of the current theories around career development and how this knowledge pertains to student recruitment into tertiary level science courses.

How do people make career decisions?

Holland's 1997 theory of vocational personalities suggests that people match their career choices to their personality type (realistic, investigative, artistic, social, enterprising or conventional) whereas Super's theory takes a developmental approach and supposes that career choice is a fluid process that develops over an individual life span (Holland, 1997; Super, Savickas & Super 1996). Both of these ideals are expressed within the Social Learning Theory of Career Decision Making (SLTCDM).

This theory describes four factors relevant to career decision making (reviewed in Niles & Hartung, 2000):

- Genetic ability: inherited traits such as sex, intelligence, athletic ability, artistic talent etc.
- Environmental conditions: social, cultural and political factors such as financial sponsorship programmes, family traditions, familial, and societal expectations.
- Learning experiences: the combinations of natural talent with positive learning experiences, exposure to positively reinforcing messages and situations such as good teachers, museums, science clubs or role models.
- Task approach skills: work habits, mental set, emotional responses and problem-solving skills.

The Social Cognitive Career Choice Model (Bandura, 1986; Fouad, Smith & Zao, 2002; Lent, Brown & Hackett, 1994) is another theory that highlights similar factors as expressed above. Under this model the important criteria for career choice are (from Hazari *et al.*, 2010):

- Curriculum elements: specific content or curriculum designs which enhance interest in a particular subject area.
- Classroom/school characteristics: class size, resourcing, public or private education, single sex etc.
- Teacher characteristics: equitable behaviour, communication, background.
- Student characteristics: educational ability, test scores, socio-economic background, self-perception.
- Relationships: with peers, family, role models.
- Out of school experiences: informal education opportunities (e.g. museums, science clubs), childhood experiences.

By examining the two theories side by side it becomes obvious that both internal and external factors are at play when developing a career choice. Both theories suggest that career decisions are linked to the development of the individual through their life history. This suggests a pattern as follows: Both theories work on the assumption that career choice stems from an internal self-interest but that this interest is subject to external forces. In addition, there is an underlying belief that career choice is linked to a student's intrinsic element of interest in the subject or career field. However, it is the author's view that this is a modern, largely Western, way of viewing career options based on limited evidence that Asian youth are more likely to be influenced by parental expectations than intrinsic factors (Ma and Yeh, 2005; Mau, 2000). The prioritising of self-interest above societal and parental judgements echoes the increasing predominance of individual self-worth that is often observed in youth culture in Western societies today. This individualism is not necessarily a negative factor but time may prove it to be a social trend rather than a stable construct.

In terms of career choice, the internal factors combine with external factors to develop a 'career identity'. Within science, development of a career identity is often thought to be heavily influenced by whether or not a student identifies with scientists and can visualise themselves as a scientist (Aschbacher, Li & Roth, 2010; Cleaves, 2005; Maltese & Tai, 2009; Stake & Nickens, 2005). This projection is described as the potential self or possible future self (Stake & Nickens, 2005) and is influenced by several factors.

The theories mentioned above provide some clues as to the drivers at play in the development of career decisions. Important external factors are parents, teachers and peer interactions and societal expectations. Balanced with this are the internal factors of self-awareness, self-motivation, development and sustained interest in a topic.

The role of parents

From the earliest age, parents are an important force in our lives; therefore it is not surprising that this influence extends to the selection of a career. The simplest analysis shows that parental education almost directly correlates to university ambitions (Roksa & Potter, 2011; Schuette, Ponton & Charlton, 2012). This is most often seen within the context of students who are the 'first-in-family' to attend university. Such students are difficult to attract into the tertiary setting and many outreach programmes are designed to work alongside these students to increase their aspirations to include higher education (Gale *et al.*, 2010).

Parental influence has been demonstrated to be one of the earliest and most powerful effectors surrounding career decisions. Buzzanell, Berkelaar & Kisselburgh (2011) interviewed 800 children from China, Lebanon, Belgium and the United States in order to examine how stable the effect of parent is on career choices across societies. Their research shows that, independent of societal influences, parents are a major influence on the perception of work and career. From as young as four years old children were aware of the work that their parents did, were internalising positive and negative impressions of work and beginning to understand different careers. The oldest children in the study were ten years old and by this stage many had made preliminary decisions about their career track. The influence of the parents was often obvious in terms of the level of ambition (aiming for careers requiring higher education or not) and the subtle support given for some subjects above others (for example choices of access to extra-curricular clubs and activities) (Buzzanell *et al.* 2011).

From the earliest age, parents guide their children in developing skills and oversee their academic advancement. As children naturally gravitate towards careers which they enjoy, and enjoyment is often closely linked to academic achievement, parents have a subtle ongoing influence on career choice (Aschbacher *et al.*, 2010; Beaton *et al.*, 1996; Shrigley, 1990; Simpson & Steve Oliver, 1990). Mothers in particular have been shown to influence self-belief in terms of career (Eccles, 2011; Eccles (Parsons) *et al.*, 1983; Jacobs & Eccles, 2000). Bleeker and Jacobs (2004) demonstrated that mothers' beliefs about their children's abilities in maths and science were shaped by gender stereotype and were highly predictive. The mothers' beliefs were also shown to influence career choice and helped determine whether or not children had an internal belief that they could achieve in science or maths (Emmanuelle, 2009; Bleeker & Jacobs, 2004).

A final role of parents is in providing financial support for a student, and mediating the transition to a higher education organisation. Parents who have negotiated their own way through the tertiary system are better equipped to assist their children with this transition, and tertiary qualified parents are more likely to be financially secure (Downs *et al.*, 2008). Parents who are unsure about the demands of higher education, or are worried about the cost, may give negative reinforcement to students, particularly if the students are wanting to follow highly competitive subjects or those with a high level of difficulty (threatening long term success) (Downs *et al.*, 2008; Kahneman & Tversky, 1984). Many widening participation projects aim to address these logistical concerns but may miss many of the subtle long-term effects of the family environment (Gale *et al.*, 2010).

The role of teachers

Particularly during adolescence, teachers exert a powerful influence on career selection. The most obvious route for this pressure is through the development of self-belief and subject-specific achievement. The role of quality teaching in student achievement is highly controversial (Cohen, 1981; Goldhaber & Brewer, 1997; Hattie, 2004; Rockoff, 2004; Rubie-Davies, Hattie & Hamilton, 2006).

Work by John Hattie demonstrates that, after the students own ability and drive to succeed, teachers are the most important factor in achievement at school (Hattie, 2004). His research over several years suggests that teachers contribute up to 30 per cent of the variance in student achievement and, as such, quality teaching is vital to the school system (Hattie, 2004). This is obviously important from a career selection point of view as a good science teacher may increase the sense of achievement of students in this area and therefore help to sustain their interest in the subject. This factor is particularly pertinent to the physical sciences, which are historically deemed difficult subjects to master (Cheng, Payne & Witherspoon, 1995; Crawley & Black, 1992). These subjects are also often linked to a parental belief of inherent ability, either you 'get' science or you do not (Bleeker & Jacobs, 2004; Eccles, 2011; Gouthier, Manzoli & Ramani, 2008; Kelly, 1981). A good teacher may be able to mould these expectations or experiences and so make science more accessible to a wider range of students. Quality science teaching is therefore an important component in sustaining scientific interest throughout a child's school career.

In addition to maintaining self-belief and supporting academic achievement, the role of the teacher often extends into the realm of mentor. Students seek teachers' views on higher education providers, possible courses and expectations of achievement (Hazari *et al.* 2010; Munro & Elsom, 2000). The teachers' own backgrounds, education, social networks and beliefs strongly influence how they communicate with the students about their options in higher education. This set of unconscious behaviours and expectations can be referred to as the teachers habitus, the 'durable, transposable dispositions' that are developed early in an individual's life and manifest in manner, style, gait and language (from Oliver & Kettley, 2010). A teacher's expectations, knowledge and sense of achievement within science can profoundly influence a student's perception of their own abilities. This is particularly relevant to the reported gender bias within the physical sciences. Teachers who believe, often unconsciously, that males are better than females in the mathematical and physical sciences transfer this expectation to their students and their understanding of their potential career options (Aschbacher *et al.*, 2010; Jones & Wheatley, 1990; Osborne, Simon & Collins, 2003).

Peer interactions and society expectations

Adolescents often seek the support and approval of peers. Peer support influences what students think is valuable, enjoyable and appropriate (Duncan, 1993; Eccles, 2011; Patrick *et al.*, 1999). These factors are closely linked to the ongoing motivation that a student has for a particular activity, and how much time they are likely to devote to developing their ability within that field (Patrick *et al.*, 1999). Stake and Nickens (2005) demonstrate that having peers engaged and supportive of science activities positively encouraged individual expectations of a future life as a scientist. Programmes which allow the participants to form social networks with scientifically-minded peers are likely to have a greater long-term impact (Davies & Kandel, 1981; Stake & Nickens, 2005).

Diverse cultures value different subjects and career choices. Asian families are reported to favour scientific careers as they are associated with long-term advantages (Woodrow, 1996). Conversely, other cultures may perceive school-based science as a Western construct and therefore struggle to connect with it (Lemke, 2001). The underlying epistemologies of science may be an anathema to cultural knowledge and therefore science may be devalued or shunned within certain cultural contexts (Cunningham, 2000). Therefore, in some cultures science is highly valued and a scientific career is seen as prestigious. In other cultures science is not a worthy pursuit and as such children are less likely to be encouraged and supported in their studies. These underlying cultural biases also affect other influencers such as parental support, peer acceptance in addition to the student's personal internal motivation (Hartung, 2002; Kim, Li & Liang, 2002).

Career counsellors and role models

Other individuals have been hypothesised to influence student career choices. However evidence from the physical sciences suggests that the impact of career counsellors, role models and guest speakers is minimal. The role of career counsellors is similar to the role of teachers, with similar issues and problems around habitus expected to be relevant. This means that the career counsellors own expectations and life experience of careers will influence their advice (Oliver & Kettley, 2010). Research has demonstrated that the effectiveness of career counselling is directly related to the motivation and abilities of the individual counsellor (Taurere, 2010). For the purposes of this work we have grouped career counsellors with science subject teachers with the intention that resources should be targeted to individuals with sufficient interest and willingness to engage with the processes.

Some studies have suggested that role models can influence, if not alter, career decisions (Maltese &

Tai, 2009). Programmes implemented around raising aspirations, especially for students from low socio-economic areas, often utilise role models to showcase possibilities outside the immediate environment of the student (Gale *et al.*, 2010). The use of role models is supported and acknowledged but their influence is often compromised by the ongoing, direct influences of parents, teachers and peers.

When do students make career decisions?

The two main forms of outreach, marketing or widening participation programmes, are largely aimed at students studying at high school. Generally the youngest students that universities interact with are at least 14 years old. The exception to this is through participation in science festivals such as 'Scientriffic' (Wrexham, Wales) or 'Incredible Science' (Auckland, New Zealand). These initiatives are generally collaborative and may target younger students through exciting science shows or experiment demonstrations. Criticism is often raised however, by faculty members that these events are a waste of resource as they don't allow direct interaction with the target audience (Bray, 2010). Should universities be trying to engage a younger audience or should resources be prioritised to students in the final years of high school? When do students make the decision about what to study?

What stands out about the student choices during high school is that negative influences are more powerful than positive ones. ... It is common for students, females in particular, to select out of science subjects as they are no longer able to imagine their future selves as scientists...

As outlined above, children are exposed to work and careers from a very early age (Buzzanell *et al.*, 2011). From as young as two or three years children are aware of their own parents' work situation and start to develop their own understanding of work options. By age five or six children can confidently answer the question 'so, what do you want to be when you grow up?' Answers are typically stereotypical (e.g. 'I want to drive trains/be a footballer/be a singer') but demonstrate that both children and adults are already starting to focus on future career options. Research demonstrates that throughout primary school students are evaluating, investigating and selecting possible career options (Brown, Ortiz-Nuñez & Taylor, 2011; Buzzanell *et al.*, 2011; Helwig, 2008; Lindahl, 2003; Schuette *et al.*, 2012; Tai, Qi Liu, Maltese & Fan, 2006). It is widely accepted that by around 10-12 years of age (late primary school) students have largely decided the general field of work that they want to be involved in (Lindahl, 2003). It is notable that these early decisions are relatively stable (Helwig, 2008; Schuette *et al.*, 2012; Tai *et al.*, 2006). When interviewing scientists and graduate students of science, Maltese and Tai (2009) highlighted a trend for people who select this trajectory to decide early in life. Sixty-five per cent of interviewees reported that their interest in science developed before their middle school years (around 11-14 years of age) with a further 30 per cent indicating that their interest in science developed during middle or high school (11-18 years). Young men tended to report an interest in science earlier than young women with 80 per cent of male interviewees declaring that they had decided on a science career before they attended high school. Female students were slightly more inclined to develop science interest during their high school years (14 per cent of female students developed their science interest in high school as compared with 10 per cent of male students) (Maltese & Tai, 2009).

By 16 years of age, roughly half way through high school, the majority of students have selected their probable career path and are starting to refine their subject options (Brown *et al.*, 2011; Lindahl, 2003; Schuette *et al.*, 2012). What stands out about the student choices during high school is that negative influences are more powerful than positive ones. During this time female students are vulnerable to influences such as poor academic performance and peer- and self-perception (Cleaves, 2005). It is common for students, females in particular, to select out of science subjects as they are no longer able to imagine their future selves as scientists (Aschbacher *et al.*, 2010; Stake & Nickens, 2005). This vulnerability to negative messages is one that is often overlooked in the development of outreach and marketing programmes.

This evidence suggests that universities often target students too late to effect real change in their career options. If outreach programmes are to attract students into science, they need to address the wide range of influences on students' lives, and engagement must be made with students while they are making their career choices. The information available to date suggests that to be effective in increasing the number of students electing to take science subjects, universities need to put in place programmes that work with students before they reach high school, and there needs to be a greater understanding of the importance of science during the primary years. The general lack of recruitment initiatives and focus on scientific literacy for younger students can compound the lack of understanding of science careers and career options (Osborne & Dillon, 2008; Education Review Office, 2012).

What turns students on to science when they are young? Why do some students gravitate towards science subjects and reject others? Evidence suggests that those students that persist with science found it interesting and fun from a young age. They felt able to achieve within the science context and they found it relevant to their world. Students that continued along the science path to tertiary study often have the support of their families and it is within accepted social norms for them to pursue a highly academic and perhaps financially risky career path. They were supported by teachers who made science fun, relevant, and achievable. This assisted them in forming peer groups where studying science was the norm that in turn allowed them the space to achieve to a high level. With all these competing factors and inputs can universities hope to have any influence? We think the answer is yes, but a rethink of how they utilise and mobilise their resources needs to happen.

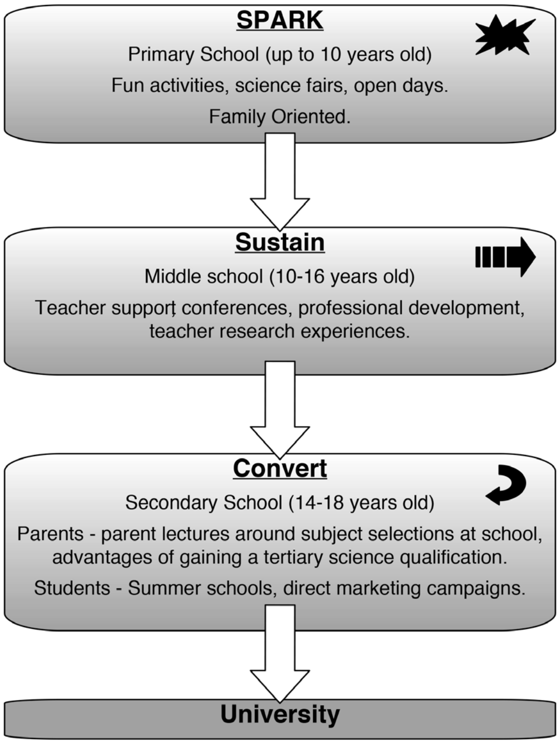

Fig. 1. An outline of a new model for universities to engage school students with science

The model

Our model rests on three key ideals; engagement with potential students needs to happen early, be sustained over the life of the student and reach beyond the student to encompass their parents, teachers and peers. This structure is illustrated in the diagram in Figure 1 and explained in more detail in the following sections.

Engagement needs to happen sooner

Based on the evidence, we believe that universities should be involved with, and support initiatives, that allow primary-aged students to participate in science. These activities should be designed to be fun and motivational, showcasing science as part of everyday life and relevant to everyone. The criticism that younger students are unlikely to follow into higher education, that the university has no place in this space, are unfounded. Higher education institutes have access to myriad resources and people that are of immense value to the primary school sector. In addition, under-graduate and graduate students can gain a wealth of skills through interacting with young students. Universities should encourage site-visits for primary aged children to allow them to view university scientific facilities (France & Compton, 2012). In terms of child development the pre-teen years are associated with a period of exploration where the individual is more receptive to new concepts; younger students are therefore more open to alternative career options (Eccles, 1999). This openness can be harnessed and built upon to open up student expectations and possible future selves.

Engagement needs to be sustained

One off, one day events are easy to run but they are unlikely to have significant impact amongst the variety of other factors in the life of a student. To be really effective the university needs to be seen as an ongoing part of the student journey (France and Compton, 2012). However, it should be realised that through their mid-teens students are uniquely sensitive to negative images (Eccles, 2011; Freeman, 1997). For this reason we suggest that this is the ideal time to support achievement through indirect channels. Career literature identifies the strong influence that role models play at this time of life, including parents, teachers, peers and career counsellors (Hodkinson & Sparkes, 1997). Engaging with students in the middle-school (intermediate) and early high school years through these alternate routes could be a key to the success for these programmes (Catsambis, 2001; Fadigan and Hammrich, 2004). The final phase of interaction is during the last two years of high school. Outreach during this time is often a pure marketing exercise, choosing one institution above another. It is not a time to convert students to science or science disciplines as these messages are likely to be lost. Few, if any, students are motivated to change their career focus at this late stage of their development (Cleaves, 2005). Programmes need to focus on the advantages (price, courses available, lifestyle and prestige) of one institution over another. Parents are also likely to be very interested in this stage of the decision-making and should not be excluded from these discussions (Maringe, 2006).

Engagement needs to include parents, teachers and peers

Universities are often very willing to talk directly to senior students but are less interested in working alongside teachers, career counsellors or parents to explore career options. This is a mistake. The literature clearly shows that these external people play an important role in guiding and supporting the individual.

Parents perform an increasingly important role in guiding the career choices of their children. The actions, expectations and prejudices of the parents are absorbed by students from an early age. One avenue for increasing the number of students in science is to increase the science literacy of the parents. Outreach programmes such as science festivals play an important role in normalising science within a family (Riise, 2008). Often the challenge is reaching out to communities and families where science is not valued; such families are not the ones that traditionally attend science fairs (Dawson & Jensen, 2011). Events that take science to non-traditional locations (supermarkets; community halls) are worthy of consideration. These events need to be supported by the provision of good written material that parents can take with them. These need to outline what careers are available in science, the earning potential for BSc graduates, what courses are available and the application pathways.

Supporting quality teaching is another key area. What makes an excellent teacher and how to support quality teaching is an issue fraught with difficulties (Hattie, 2011), a complete discussion of which is beyond the scope of this paper. However, ongoing discussions on how universities could support quality teaching should be encouraged and it should be noted that supporting local teachers has a multiplying effect, each teacher will be teaching between 20 and 100 students a year and perhaps 4,000 students over a lifetime. Teachers can be a university's best advocates. Great teachers help develop great scientists; their influence should not be underestimated (Munro & Elsom, 2000). We would suggest that universities working to support and develop teachers, through offering continuing training and science upskilling through access to university resources, is an effective and cost-minimal way to increase engagement. A vast array of such programmes have been undertaken worldwide with the best examples using a partnership model and mutual cooperation to have an ongoing impact on student engagement and learning (Richmond, 1996; Tanner, Chatman & Allen, 2003). Teacher open days have been used successfully to market universities to teachers but this should be used with caution around the habitus of the teacher (Oliver & Kettley, 2010).

Peers are also important. To develop peer relationships we suggest that at least some programmes are formed to challenge school groups. If a student is able to remain within their normal cohort of friends, and this group is anti-science then it is unlikely that the student will feel comfortable pursuing study in science. Activities such as summer schools, site visits and research days which allow for group interaction (not merely sitting in a lecture group for a day) are all valuable tools for introducing students from a range of backgrounds into a science-supportive environment (Jacobs *et al.*, 1998; Packard & Nguyen, 2003). Institutions should be looking to provide environments where a student who may be isolated in terms of science interest in their local school can develop networks with peers that support and encourage science achievement, even if this is maintained across geographical boundaries.

We suggest universities work towards an integrated policy for recruitment for students into scientific courses. This should start with sparking an interest in science (at primary level), through science fairs or outreach programmes that target both parents and children. The second phase (through intermediate and lower secondary) should sustain interest. This is best achieved through an indirect method particularly through working with teachers. Models for this might include teacher professional development courses or teacher conferences and may involve either on site visits or outreach programmes as appropriate. The last phase is to convert a student's interest in science into tertiary enrolments which can be done through open days, marketing material and summer schools. Marketing material needs to be inclusive of parents and caregivers as they are highly influential in decision-making at this time.

Of course, it is accepted that currently many of the suggestions presented here are not supported by data – proving effectiveness. Many of the programmes outlined here as suggestions and examples have been drawn from the author's personal experiences and conversations. With many of these projects there is little or no resource (money or time) to complete comprehensive evaluation of the programme. This is coupled with wide-ranging problems in evaluation including under-resourcing, biasing towards success (to ensure ongoing funding), confidentiality clauses or just confounding by the huge range of factors that encompass career selection. Measuring the success of ventures such as open days, outreach programmes and teacher partnerships with sufficient power to prove effectiveness is almost impossible. Therefore, we have instead provided examples and ideas of programmes that we have experienced to highlight how a university might begin to develop a strategy of engagement. Wide-ranging reviews of the literature suggest that a model such as we have outlined, starting with younger age groups, involving teachers and parents and building to a pure recruitment drive, may be a logical way to develop or reform recruitment strategies. We have also provided a wealth of research to help those developing programmes to understand career influences and help them synthesise the salient factors so that they can produce a tailored and evidence-based strategy for student recruitment and engagement. However, the authors accept that until such programmes are actually put to practical use their true worth cannot be determined. We strongly encourage programme leaders and their managers to include robust evaluation measures into their work. To this end, the authors themselves are currently undertaking a programme of research to determine the ultimate value of the strategies presented here.

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